SAARC EXPERT GROUP MEETING
ON
LANDSLIDE TERMINOLOGY, CLASSIFICATIONS, DOCUMENTATION AND HAZARD MAPPING

SAARC

Jointly Organized by
SAARC Disaster Management Centre, New Delhi
and
Geological Survey of India Training Institute Hyderabad
Hyderabad, India

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Overview

One of the major natural disasters to strike the South Asian countries with recurring frequency, the landslides cause enormous amount of economic loss to the SAARC member states in addition to inflicting loss of life to the affected communities. Rapid urbanization in these countries added with other elements like upscaled deforestation, unstable slope conditions in many parts, inherent failure planes present in the rock units and high precipitation are some of the controlling factors for causing landslides in these countries. The current science and practice of landslides risk management in South Asia is far removed from the state-of-art tools and techniques of landslide mitigation and management. Although such tools have been applied in few areas to protect vital slope and infrastructure, application of such tools in engineering practices are not generally contemplated due to capacity and cost constraints. No much success has been achieved in developing region and location specific cost effective solutions. While technical and operational guidelines have been developed for landslide risk mitigation in a few countries and some innovative and solutions have been implemented in some places, sharing and exchange of learning and good practices among the countries of the region are almost non-existent. Scientists, engineers and environmentalists from South Asia have been making significant contributions on landslide research in many institutions in the region and outside, but a South Asian forum of landslide experts is not in place to learn from each other's experience and collaborate with regional and global institutions. In short, there are many shared interests and large gaps in landslide risk management in South Asia which offers huge scope for regional cooperation among the countries of South Asia.

The recent statistics show that the loss of life due to landslides in South Asia is a matter of serious concern in South Asia. In the year 2010, Bangladesh suffered the maximum loss of life (29%),

followed by Nepal (25%), India (23%) and Pakistan (21%) whereas Afghanistan brought up the rear with 2% of the total loss of life due to landslide incidences in south Asia (Figure 1). However, the analysis of the number of people killed in South Asia between 2007 and 2010 shows an overall decreasing trend (Figure 2).

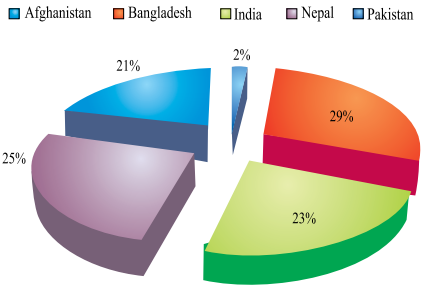

Figure 1: Percentage of people killed in South Asia due to landslides in the year 2010 (SDMC 2010).

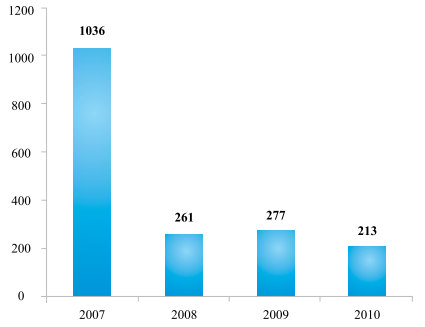

Figure 2. People killed in South Asia between 2007 and 2010 due to landslides (SDMC 2010).

Landslide studies in south Asia has not received required focus. The study of individual slide and basin and region wise studies have been initiated in the early eighties. The definition, terminology, and classifications scheme used to describe landslides in the region are non-uniform. Individual, organization and academic institutions have been using different terminologies and classification schemes to describe small to large landslides, which has put more difficulties, ambiguities and complexities to describe individual landslide. Similarly, for landslide hazard mapping there is no uniformity on scale, methodology and parameters to be considered. Therefore, for the systematic study of landslide and hazard zonation mapping, there is a need of development of common procedure to use terminology, classification scheme and mapping methodology. In this context, SAARC Disaster

Management Centre (SDMC) is proactively working on landslide hazard. The proposed expert group meeting is one of the preparatory works to bring common consensus among the scientist, researcher, professional and disaster manager on landslide terminology, classification and hazard zonation mapping and template development for documentation.

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SAARC Road map on landslides

In order to review the current strength and capacity of the South Asian countries for landslide risk management, assess the critical gaps, identify the possible areas of regional cooperation and develop a Road Map for such cooperation in short, medium and long time frame, the SAARC Disaster Management Centre organized a Workshop on Landslide Risk Management in South Asia on 11-12 in Thimphu, Bhutan in collaboration with the Ministry of Home and Cultural Affairs of the Royal Government of Bhutan (SDMC 2010).

The Workshop recommended the following Roadmap for Regional Cooperation for Landslide Risk Management in the region.

A. Landslide Risk Assessment

Most of the countries of the region have not been able to assess the hazards, vulnerabilities and risks of landslides in a holistic and comprehensive manner. It was noted that the countries of South Asia, and sometimes different agencies within the same country, have been following different classification system, terminologies, methodologies and scales for landslide hazard zonation mapping. The workshop recommended that an Expert Group may be constituted under the auspices of the SAARC Disaster Management Centre to critically review the current practices of landslide hazard zonation mapping in the countries of South Asia and develop commonly acceptable guidelines on landslide hazard zonation mapping, landslide terminology and classification system in the light of the global state-of-the-art practices. The draft guidelines so prepared shall be circulated to the Member States and peers in South Asia for comments and validation. Based on the comments received the Expert Group shall finalize the guidelines for adoption by the Member States.

B. Landslide Inventories

None of the countries of South Asia has been able to develop a comprehensive database and inventory of landslides. The global database on landslides does not adequately capture the frequency and intensity of landslides of South Asia. The workshop recommended that a comprehensive database of landslide disasters in each country of the region since 1990, to the extent it is feasible, shall be developed and the same shall be updated on an annual basis under the auspices of the SAARC Disaster Management Centre. The Centre shall develop a template for documentation of historical and current landslides through consultation among experts of the region and further prepare guidance notes for documentation. The information thus collected shall be compiled, analyzed and further validated through consultation among experts before its dissemination.

The workshop further recommended that the SAARC Disaster Management Centre should bring out a publication on the Major Landslides in South Asia. Every Member State may be requested to document case studies on catastrophic landslides in their own country, to be compiled, and published by the SAARC Disaster Management Centre.

C. Early Warning of Landslides

The workshop recognized that unlike earthquakes, most recurrent landslides could be predicted through a timely systematic programme of detailed engineering geological, geotechnical and hydro-geological and hydro-metereological investigation, instrumentation, modeling and real time monitoring. It was noted that some of the countries of South Asia have developed early warning system of landslides in specific local areas through a combination of instrumentation and community based interventions. It was recommended that the SAARC Disaster Management Centre shall take the initiative to document such initiatives, and examine the strength and constraints of such of such initiatives.

Based on this study the SAARC Disaster Management Centre shall develop a few pilot projects on landslide early warning system on cost sharing basis in selected countries, as may be willing, in collaboration with reputed scientific and technical organizations within or outside the region. The Centre shall develop guidelines to encourage Member States in the formulation of such projects.

D. Landslide Risk Mitigation

The risks of landslides can be reduced significantly through a combination of structural and non-structural measures. The package of measures to be adopted for landslide risk mitigation would depend on the unique site conditions of specific landslides. The workshop recommended that the SAARC Disaster Management Centre may take the initiative of preparing a Compendium

on the Best Practices of Landslide Risk Mitigation in South Asia region for the benefit of researchers andpractitioners in the field. The compendium would include engineering and non-engineering solutions and community based interventions for landslide mitigation.

The workshop felt that the current retrofitting programmes for seismic safety in the region stops at retrofitting of the superstructure of buildings. This practice is grossly unsafe inasmuch as even the retrofitted buildings will fail, if the slopes on which they are supported fail by sliding. The workshop recommended that the SAARC Disaster Management Centre may develop guidelines on evaluation of slope stability and strengthening of slopes based on the global best practices.

E. Training and Capacity Building

For national landslide hazard and risk assessment programmes to be successful it is imperative that highly trained professionals man the mapping teams. The workshop recommended that the following steps may be taken in this regard:

SAARC Disaster Managemen Centre should dsign highly ocused thematic training programmes and implement them in association with leading landslide experts and well established institutions. Some of the topics which need to be covered in such programmes are

(a) Field orientedengineering geological, geomorphological, hydro-geological, hydro-metereological and seismo-tectonic mapping at large scale (b) GIS based integration and analysis of thematic maps (c) Geotechnical Characterization of Slopes and Stability Analysis in terms of total and effective stress (d) Strengthening of problematic slopes, (e) safety of human settlements in landslide prone areas

The experts and institutions to be engaged to deliver the training programmes should be charged with the responsibility to develop high quality training manuals in each area selected for training

F. Landslide Response, Recovery and Reconstruction

Every year many lives are lost and many persons get severe injuries due to landslide disasters. Search, rescue and evacuation of landslide victims require specialized skills and practices. While many countries of South Asia are developing specialized response forces, in most of the countries search and rescue operations are still carried on in not a very professional manner. The workshop noted that the SAARC Disaster Management Centre is on the process of setting up a Natural Disaster Rapid Response Mechanism and recommended that the SAARC Disaster Management Centre may develop guidelines for landslide response and organize special programmes for response agencies to expose them to the best practices, including the technological options available for search and rescue operations.

G. South Asian Landslide Forum

The workshop recommended that the SAARC Disaster Management Centre should take the initiative of setting up a South Asia Landslide Forum which will comprise of landslide experts and practitioners and scientific, technical and research, and professional organizations working for landslide risk management in the region. The Forum will work for the networking and integration of knowledge and practice on landslide risk management within the framework on South Asia Disaster Knowledge Network. The Forum shall organize a Regional Conference on Landslide Risk Management once in two to three years.

Landslide studies: A brief review

Landslide Terminology and Classification

In general landslide is defined as down slope movement of any detached mass of soil or rock. There are many terminologies for landslide itself. Mass movement, slope movement, slope failure, and mass wasting are the terminologies that have been frequently used to describe landslide synonymously. It was Sharpe

(1938) who first introduced several terminologies to describe landslide more scientifically. After him, some other remarkable works have been done to develop terminologies and classification schemes (e.g. Cambell, 1951; Varnes, 1978; Cruden and Varnes, 1996 etc). Despite such remarkable works and literatures, still there is lack of systematic use of developed terminologies globally. Such practices of using terminology have created confusion among the scientists, practitioner, and professionals working on landslides.

The history of landslide classification goes back to 1938 when Sharpe gave his first classification system that considers type of movement, material type and role of water and ice as prime factors. He considered speed of the movement as a secondary parameter. In this classification, it was considered that slope move movement is only due to action of water and ice and do not say anything about other anthropogenic and natural forces like earthquake. Hutchison (1968) gave field based classification of using type of movement and morphology. The movement criteria of Hutchison include depth, direction and sequence of movement with respect to the initial failure. Varnes (1978) proposed more comprehensive classification of landslide taking material involved and type of movement which later adopted by Landslide Committee, Highway research Board of USA. Types of movement have been divided into falls, topples, slides, lateral spreads and flows and the combination of two or more movements is termed as complex. Similarly, material involved has been divided into rock and soil and soil further divided into debris and earth (fine soil). Till date it is the widely used classification of landslide globally. Later in 1996, Cruden and Varnes (1996) proposed a new scheme of landslide classification using primarily type of movement and secondarily type of material involved. In this classification factors such as velocity, depth and water content in the materials can be added as adjective to name the slides. This classification was adopted by the

international Association of Engineering Geology (IAEG) Commission on Landslide and Working party on World Landslide Inventory (International Geotechnical Societies and UNESCO). Now it is clear that none of the classification system covers all types of landslides and is complete. The bases and parameters used for classification are broad and not determinable in all environments. Having such verities of classification, today scientists, professional and experts are using different classification system to fulfill required needs in south Asia. In this regards SDMC puts efforts to bring common consensus to adopt comprehensive classification system suitable for mountain and hill tracts of south Asian region.

Landslide Hazard Zonation Mapping

The aim of Landslide Hazard Zonation (LHZ) Mapping, which is essential for risk assessment, is to determine the spatial and temporal extent of a landslide hazard. In general the LHZ map divides the landslide prone hilly terrain into different zones according to the relative degree of susceptibility to landslides. This requires the identification of those areas that are, or could be affected by landslides, and the assessment of the probability of such landslides occurring within a specific period of time. Commenting on the time domain of landslide occurrence through zonation mapping is a difficult task. Due to conceptual and operational limitations, landslide hazard zonation is conceptually stated as Landslide Susceptibility Zonation (LSZ). The spatial prediction of landslides is termed as landslide susceptibility, which is a function of landslide and landslide related internal factors (i.e., ground characteristics). The aim is to identify places of landslide occurrence over a region on the basis of a set of physical parameters. LSZ can be formally defined as the division of the land surface into near-homogeneous zones and then ranking these according to the degree of actual or potential hazard due to landslides. The LSZ maps do not directly incorporate

the time and magnitude of landslide occurrences. Since LSZ is conceptually accepted as LHZ, it is popularly referred to as LHZ in south Asia. LHZ mapping serves as one of the many components in landslide risk assessment. The methodology to develop landslide hazard map depends upon several factors like nature of terrain, parameters to be considered, available data on geology, soil, slope, rainfall, seismicity etc. For the simplicity, we can discuss available methods in three groups; Heuristic Approach, Statistical Approach and Deterministic Approach.

Heuristic Approach

Heuristic approach is a kind expert driven field based approach for landslide hazard mapping. It is based on geomorphological survey of the terrain for inventory of landslide and geomorphological setting. This can be done using two methods, first geomorphological analysis or direct mapping of the terrain and second by qualitative methods. The qualitative methods of hazard assessments based on superimposition of qualitative maps like geological map, hydrological map, slope map, land use map, soil type and depth map etc.

Statistical Approach

The statistical approach of landslide hazard analysis considers the causative factors that led to landslide occurrence in the past. Such factors are determined statistically and quantitative predictions are made for the terrain with similar failure condition. In this method input and output data are related to by an empirical parametric function. The parameters used in this function are not related to physical parameters that can be determined in the field or in the laboratory. Further, the underlying physical process is considered as absent or neglected. Using this method, a temporal prediction of landslide hazard zonation is possible. In general, there are two types of statistical approaches in common use; Bivariate and Multivariate analysis.

Deterministic Approach

This method is based on slope stability analysis and allows us to compute quantitative values of slope stability factor, i.e. factor of safety of the slope. This physically based approach depends on engineering principles of slope instability expressed in terms of factor of safety. Basically, for this purpose parameters are derived/determined from the laboratory experiments. Due to need of exhaustive data from unstable slope, this method is often only effective for mapping small areas.

Landslide studies: The South Asian Scenario

Available literatures show that Nepal is the first country to introduce landslide hazard mapping in South Asia. It was Wagner who started Landslide Inventory Mapping in Nepal in 1983. After him Keinholz et al. (1984) developed much improved landslide Susceptibility Mapping Technique. The paper published by Keinholz (1985) presented a methodology for assessment of slope stability in the Nepalese middle mountains for the densely populated hill areas. This work was continued by Zimmerman in 1986 and White in 1987. Among the several methods available for landslide hazard mapping, the method proposed by Deoja et al. (1991) has been widely applied in several landslide hazard mapping projects in Nepal, especially along the road corridors. This method requires the preparation of thematic maps, which deal with engineering geological concerns such as engineering geological, slope and aspect as well as hydrological and land use conditions. The data for engineering geological conditions are acquired by the study of aerial photos, topographical and geological maps, and fieldwork. The landslide hazard map is finally prepared by superimposing all of the concerned maps and other relevant data. For the production of the final hazard map, ratings are given to the state of nature, average annual rainfall, danger and triggers, and then the values are summed up. In this method, soil slope hazard maps and

rock slope hazard maps are prepared separately. The hazard levels are categorized as low, medium and high depending upon the total value of ratings. This method has been widely used in Nepal as well as other south Asian countries. International Centre for Integrated Mountain Development has developed a comprehensive training manual in six volumes for middle level professionals. In later years application of GIS gave a big thrust to the mapping work. Department of Mines and Geology (DMG), Government of Nepal is a government institution engaged in the study of landslides and mass wasting phenomena. In Nepal, DMG has already prepared landslide hazard map for major urban areas incorporating engineering as well as environmental aspects. Currently, there is a range of hazard maps for the major urban areas as well as major road corridors of Nepal. However, the scale and parameter considered for mapping varies with nature of terrain and requirement. For the regional study, 1:25000 to 50000 is very common scale whereas for the individual project up to 1:10000 is in use.

The terrain friendly mapping techniques developed for Nepal Himalaya later widely applied in other SAARC countries, for example, Bhutan, India and Sri Lanka. Bhutan has been putting her efforts on Landslide Hazard Zonation mapping gradually. Department of Geology and Mines and Department of Road have been actively working on various aspects of landslide hazard and risk management. Bhutan has established Department of Disaster Management under the Ministry of Home and Cultural Affairs to look after natural as well as man-made disasters. It has been prioritizing the landslide studies for sustainable disaster management in the country.

India has carried out considerable work on landslide hazard zonation mapping. Apart from the individual studies for road corridor and watershed, BMPTC has published first small scale landslide hazard map of India in October 2003 and released on 30 January 2004. The strategy and the approach to landslide

hazard mapping used were based on the current state-of-the art, taking fullest advantage of the enormous amount of information and data on Indian landslides, mostly published and some unpublished. The available thematic factor maps of India were used in hazard mapping on a GIS platform. A high degree of match was found between observed and predicted landslide hazard. The National Remote Sensing Agency of the Department of Space of the Government of India published two volumes of Atlas on Landslide Hazard Zonation. The Atlas, Volume 1 refers to the State of Uttaranchal and Volume 2 to the State of Himachal Pradesh. The pilgrim routes were targeted in mapping to a scale of 1:25 000. In India scale of mapping and parameters taken for landslide hazard mapping varies according to nature of terrain and project scale. Usually detail landslide hazard maps have been prepared for urban area, road corridor and hydropower projects.

In Pakistan, there were scattered studies on landslides. Initially, Landsat imagery and aerial photographs were used to broadly demarcate and identify critical areas in order to prepare surface maps which are imperative for landslide studies. Landslide inventory maps of different areas were prepared to mark areas with different degrees of stability along the Kohala-Muzaffarabad Road, Azad Kashmir (Saeed and Malik 1990). Demarcation of areas as stable, unstable, and potentially unstable zones was carried out along different important routes on the Murree-Muzaffarabad Road and the Karakoram Highway. The critical areas (unstable and potentially unstable) were studied in greater detail for analytical purposes. The geological Survey of Pakistan has been conducting landslide hazard studies across the country through its state offices. Recently, Geological Survey of Pakistan (2006) has published book on Landslide Problems and their Mitigation along the Karakoram Highway. This has comprehensively documented data on slide type, morphology, geotechnical studies etc. The World Health Organization (2007)

published landslide hazard distribution map that depicted landslide hazard as very low, low, medium, high and very high.

In Sri Lanka, the main causes of landslide are fragile geology, heavy rain fall and unwise human intervention on vulnerable slope. Most of the landslides, rock and cutting failures occur in the central highland of the country which is composed of highly fractured and folded basement rock overlain by residual soil and colluvium. It is about 20% of the total land area and is occupied by 30% of the total population of the country. An area of nearly 20,000 km^2 covering the districts of Badulla, Nuwara Eliya, Ratnapura, Kegalle, Kalutara, Kandy, Matale, Matara, Galle and Hambantota is prone to landsliding. Several initiatives have been taken to reduce the risk of landslide in Sri Lanka. The Government of Sri Lanka along with UNDP/UNCHS has been actively working on landslide hazard mapping since 1989. The Government of Sri Lanka has initiated several phases of landslide hazard mapping and dreamed to accomplish by 2011. For this project, National Building Research Organization was designated as the nodal agency for landslide management in the country. National Building Research Organization has in place a well established and highly acclaimed programme of completing the Landslide Hazard Mapping of the entire country at a scale of 1:10 000.

In Bangladesh, landslides mainly occur in Chittagong area, Madhupur and Barind tracts of the Dhaka and Rajshahi districts. Among them Chittagong area of Bangladesh is badly affected by rain-induced landslides which usually receives rainfall of the order of 3000 mm. Every year there are numerous incidents of landslide that claim number of lives and huge loss of property. The Government of Bangladesh has established Ministry of Food and Disaster Management to formulate policies prepare plans, develop national capacities and look after all aspects of disaster including mitigation and management. Disaster Management Bureau has been established under the ministry sup-

ported by many committees constituted at various operational levels. There are many scattered studies on engineering geological studies on landslides. Systematic landslide hazard mapping is yet to carry out in Bangladesh.

The northern and north-eastern parts of Afghanistan, such as the Badakshan's Hindu Kush and Pamir mountain ranges are prone to landslides. Owing to its location in the tectonically active southern part of the Eurasian plate, the frequency of earthquakes is comparatively high in Afghanistan, which in turn induces many landslides particularly in the northern and eastern belts. There are few studies on landslides carried out by researchers and academic institutions. The Government of Afghanistan has established the Afghanistan National Disaster Management Authority to manage disasters. It is working very closely with the UNDP to unfold a Comprehensive Disaster Risk Reduction Programme (CDRRP). It has also come up with important programmes on slope degradation and erosion and landslide. Recently, the World Health Organization (2007) published regional scale landslide hazard distribution map that depicted landslide hazard as very low, low, medium, high and very high for the entire country.

Landslide Studies in South Asia: Existing gaps

From the above review it is understood that there is no uniformity on use of landslide terminology to describe different type of landslide and mass movement. Since there are many classification systems based on material involved in the process, mechanism of failure, and rate of movement of the rock mass, therefore scientists, professionals and researchers from south Asia are adopting various styles of classification as per their requirement.

Landslide hazard zonation mapping has been initiated in early eighties, even though no common methodology and standard has yet been adopted. As mentioned above, the South

Asian countries are adopting different methodologies like heuristic approach, statistical approach and deterministic approach. Each methodology varies from country to country and parameters for hazard zonation mapping have not yet been properly assimilated for the region. This is one of the challenging issues to be discussed for the development of common standard for mapping. South Asia, mainly Himalayan belt has witnessed many devastating earthquakes in the past, which induced massive landslides in the region causing huge loss flora and fauna. For example, in 2005 Pakistan earthquake only, it is estimated that about 25000 people lost their life due to earthquake induced landslides. Despite such losses earthquake induced landslides are not getting proper attention in landslide study. Therefore, the current practices of landslide hazard zonation mapping should also include dynamic forces like micro and macro earthquakes. Similarly, incorporation of rainfall threshold value in the hazard map is another important and crucial parameter required for precise assessment of degree of geological hazards. Thus it is expected to undertake a comprehensive discussion on these gaps and weaknesses extensively during the meeting.

Proposed Agendas for Discussion

The available literatures on landslides have shown that, in south Asia, there is no uniform and widely accepted usage of terminology and classification system. Because of such practice, there are several difficulties among the scientists, researchers and professional to communicate research on landslides. Similarly, methodology and scale on landslide hazard zonation mapping varies from country to country in terms of parameters considered and scale. Therefore it is expected to discuss following agendas extensively among the experts from SAARC member countries to bring common consensus on landslide terminology and classification and method on landslide hazard zonation mapping.

- Review the existing landslide terminologies and classification systems and propose most suitable terminologies and system of classification for south Asian terrain
- Discuss the existing scale of landslide hazard maps and proposed apposite scale of landslide hazard map of different purposes
- Review on current practices of Landslide hazard mapping in the member countries and recommend appropriate method
- Discuss and propose suitable methods for the documentation of landslide in the region.

Expected Outcomes

- Following are the expected outcomes of the meeting.
- Recommendation of common landslide terminology and classification system
- Review of current practices of landslide hazard zonation mapping in South Asia including methodology and parameters to be considered
- Adoption of terrain friendly method of landslide hazard zonation mapping for South Asia
- Development of template for landslide documentation

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